Mechanical Coordination

OBJECTIVE

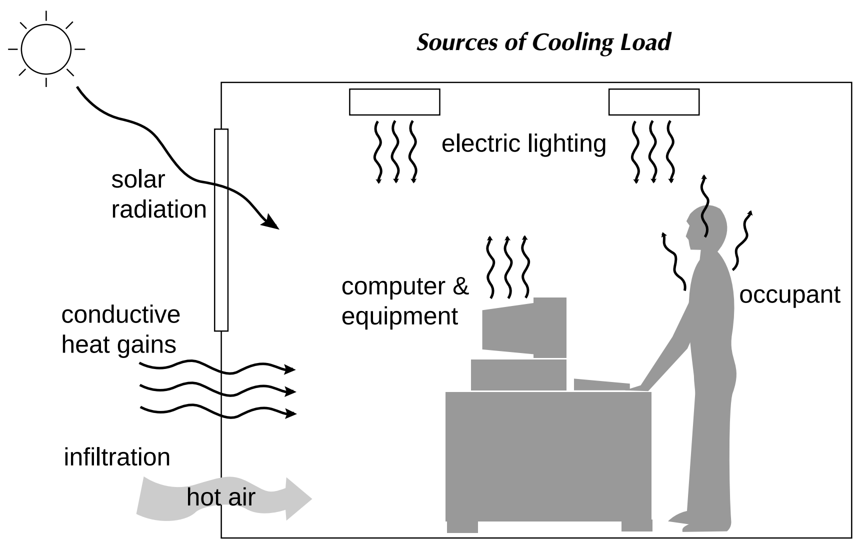
Design an efficient mechanical system to take best advantage of cooling load reductions due to daylighting and shading.

- Mechanical savings are a key element in the cost-effectiveness of daylighting.
- Efficient mechanical system design requires good coordination between the mechanical engineer and the rest of the design team.

KEY IDEAS

Help Guide Early Architectural Decisions

Sources of Cooling Load



- **Try to reduce cooling loads.** Look for opportunities where architectural decisions can save operating costs, reduce mechanical first costs, and reduce mechanical space requirements. Reducing cooling loads provides many benefits. Smaller mechanical rooms and shafts yield more leasable space. Smaller plenums allow higher ceilings (an interior amenity, also helpful for daylighting performance) or possibly additional floors within building height allowance. Smaller equipment is less visible on roof and easier to accommodate within normal floor-to-floor heights.
- **Calculate building energy use starting in schematic design**, even if this requires many assumptions about unknown details, and refine the calculation as the building becomes more defined. This early data can be critical in guiding architectural decisions, before important siting and envelope decisions are set.
- **Mechanical engineer should be an integral team player from the beginning**. Integrated design means all team members influence important building elements, and mechanical concerns can help keep architectural decisions on the right track. This is a departure from the traditional model of building design procedure, where the mechanical engineer enters the design process after major architectural decisions are already established. Mechanical expertise is not fully capitalized if not used in all design stages.
- **Assist in an optimal glazing selection.** Stay up to date on glazing technologies - dark or reflective glazings are no longer the only choices for solar heat reduction. Consider carefully the radiant effect of windows on comfort when weighing the benefit of an improved U-value or the disadvantages of a darkly tinted glazing. The mechanical system typically will respond to air temperature, yet occupant comfort in perimeter zones is highly affected by mean radiant temperature. Glazing with a poor U-value has a cold surface temperature in winter, while a dark (highly absorptive) glazing can get very hot in direct sun.

- **Encourage the use of effective shading.** Cooling loads and occupant comfort will benefit. Mechanical equipment savings may offset some costs of shading devices.
- **Remember that windows and skylights are not necessarily an HVAC penalty**. Careful daylighting design with shading can result in lower cooling loads than with electric lighting, even if glazing area is large. Proper modeling with energy analysis software that calculates daylighting with dimming controls is needed to show this.
- **Use accurate glazing and exterior shading device properties in final load calculations, not generic values.** Use manufacturer's data for architect's preliminary glazing and shading device selection. Model it accurately in calculations to estimate the full mechanical benefit from reduced solar load. Since there is no guarantee that interior shades will be closed at appropriate times, mechanical engineers typically do not include these devices in their calculations.
- **Keep ceilings uncluttered**. Try to place the lighting system's ceiling-mounted photosensor so that incoming daylight remains unobstructed by HVAC or other equipment.
- **Flag potential conflicts early**, such as inadequate space allocation, poor location or access for equipment rooms, and crowded ceiling plenums.

Reduce First Costs

- **Calculate peak cooling load and energy use with reduced perimeter electric lighting load and size mechanical system accordingly.** Be sure to specify proven and reliable daylight controls that will dim or switch electric lighting during peak cooling conditions.
- **Examine cooling system downsizing opportunities with various glazing and shading options**. Work with architect in possible fine-tuning of window sizing, window location, shading strategy and glazing selection for a smaller and more efficient system.
- **Insulating glazing may eliminate the need for a terminal reheat system at the perimeter in moderate climates**. Winter morning warm-up may be accomplished by the central heating system with appropriate controls. In addition to the energy savings, first costs may be lower with improved glazing versus the added mechanical equipment.

Reduce Operating Costs

- **Calculate the annual energy saved with improved fenestration elements.** Even if there are no mechanical first cost savings, reduced operating costs decreases the payback period. Calculations will show some of the benefit of exterior over interior shading, lower solar heat gain coefficient glazings, and daylighting controls. Be sure to account for cost savings from lower demand charges if appropriate.
- **Select an effective energy management system** to optimize building operation and tie together all HVAC, lighting and automated shading controls.
- **Set a larger temperature dead band for circulation spaces.** Let these and other non-critical spaces drift more than task areas.

Maintain Thermal Comfort

- **Window and shading design are strongly linked to perimeter zone comfort, regardless of air temperature.** Hot or cold glass behaves like a radiant panel and affects occupant comfort independent of air temperature. The asymmetric nature of this heat gain or loss is an added discomfort. Occupants will respond by adjusting the thermostat, wasting energy without satisfactorily improving comfort. Similarly, unshaded direct sun striking occupants causes discomfort independent of air temperature. Consider comfort as seriously as energy when advising architect on fenestration design.
- **Consider the effect of the window's mean radiant temperature on thermal comfort.** Dark tinted glazings or absorptive window films increase the window's surface temperature significantly in summer. Poorly insulated windows (high U-value) decrease the surface temperature in winter. Since the mechanical system controls the room's air temperature, occupants near the windows can be very uncomfortable. As noted above, a low U-value and low solar absorption will keep the glazing surfaces closer to room temperature. Radiant heating and cooling systems can provide some advantages in control of the thermal environment but are not yet commonly used in buildings.

INTEGRATION ISSUES

ARCHITECTURE

Provide adequate space for mechanical equipment or system efficiency may be impaired. Allow for adequate maintenance access.

Architectural decisions that reduce heating and cooling loads mean less space required for equipment—smaller mechanical rooms, smaller shafts, less ceiling plenum height.

Resolve aesthetic concerns with visible mechanical elements such as exposed ducts, diffusers and grilles, facade louvers and rooftop units.

INTERIOR

Tall partitions may disturb intended air flow for open plan offices.

Diffusers, grilles, exposed ductwork and thermostats may be important visual elements to coordinate. Contractors should be given accurate placement specifications that meet functional and aesthetic desires.

LIGHTING

Diffusers and light fixtures should be coordinated; fixtures may disrupt the intended air flow if surface-mounted or pendant-hung, or if placed too close to diffusers.

Account for effect of lighting control on lower heat gains from electric lighting.

COST-EFFECTIVENESS

An efficient mechanical system reduces operating costs.

A building with reduced mechanical loads requires less mechanical equipment space and therefore yields more leasable space.

A thermally comfortable building retains tenants.

A cost/benefit study will show the tradeoffs available between architectural and mechanical elements; advanced glazings and effective shading devices can reduce mechanical first and operating costs.

OCCUPANT COMFORT

Remember that thermostats don’t respond to surface temperatures.

Increase thermal comfort by washing large glazing areas with conditioned air (reduces radiant heat transfer). However, there may be a cost penalty associated with such a design.

PROVISOS

- Simple load calculations do not accurately model the energy behavior of windows, due to the complexity of window behavior and properties. Use these tools to understand general trends. Use more refined tools that properly model glazing, shading, and daylight to help make final decisions.
- Energy calculations sometimes indicate that single pane glazing is more desirable than insulating glazing for commercial buildings in mild climates. This has not been empirically supported. Remember that modeling software does not always account for all of the complex physical behavior of buildings.

- Solar heat gain coefficients for interior devices should be selected to represent achievable performance. Additionally, manually operated interior shading should not be considered a reliable means for solar heat gain reduction due to unpredictability of user behavior.

TOOLS & RESOURCES

- **ASHRAE** The American Society of Heating, Refrigerating and Air Conditioning Engineers offers a wide range of technical support materials, including the monthly *ASHRAE Journal.* Call 800-527-4723 for a publications list. For *ASHRAE Journal* subscriptions , call above number or 404-636-8400.
- **Books** ASHRAE has many book titles available addressing maintenance (see above), including the useful *ASHRAE 1995 HVAC Applications Handbook* and *1993 Fundamentals Handbook.*

  Mechanical and Electrical Equipment for Buildings, 8th Ed. by B. Stein, J. Reynolds and W. McGuinness (Wiley and Sons 1992) is a good general reference.

  Building Control Systems by V. Bradshaw (Wiley and Sons 1985) is another helpful general reference.
- **Utility Company** Many utilities offer incentives for energy-efficient mechanical equipment. Inquire at your local utility about new construction or retrofit programs.
- **Load Calculations by Hand** This method is cumbersome and rough, but acceptable for a first cut at peak energy demand. ASHRAE publications and the books above are good sources for instructions.
- **Energy Analysis Software** These programs simulate building energy use, a useful way to compare energy-efficient alternatives, estimate energy costs, perform life cycle cost analysis, show Title 24 compliance, estimate peak power demands, disaggregate energy end uses, and—most commonly—compute loads for HVAC equipment sizing. These programs require extensive learning time and subsequent user experience. Simpler, easier-to-use analysis software exists but is not helpful for daylighting design. Partial list of energy simulation software (not all may model daylighting or are approved to show compliance):

*DOE2.1E	Lawrence Berkeley National Laboratory	(510) 486-5711
*ADM-DOE2	ADM Associates	(916) 363-8383
*CECDOEDC	California Energy Commission	(916) 654-5106
*DOE-24/Comply-24	Gabel-Dodd Associates	(510) 428-0803
*DOE-PLus	ITEM Systems	(206) 382-1440
*PRC-DOE-2	Partnership for Resource Conservation	(303) 499-8611
*Micro DOE2	Acrosoft International	(303) 696-6888
*VisualDOE-2.0 for Windows	Elex & Associates	(415) 957-1977
BLAST	BLAST Support Office	(800) 842-5278
Trace 600	The Trane Company	(608) 787-3926
HAP	Carrier Corporation	(800) 253-1794
ASHRAE/IESNA Stnd.90.1 Compliance & ASHRAE Publications		(800) 527-4723

* For a list of software companies selling versions of DOE-2, contact LBNL.

- **Consult the Uniform Building Code and Uniform Mechanical Code** for compliance issues. In California, consult the Title 24 energy codes.
- **Energy Consultants** Helpful for additional daylighting expertise, software analysis, Title 24 compliance and mechanical system optimization. Easiest to find through the California Association of Building Energy Consultants (CABEC), 2150 River Plaza Drive, Suite 315, Sacramento, CA 95833-3880, (916) 921-2223.

☑ CHECKLIST

1. Discuss comfort and loads with architect prior to final envelope design.
2. Do energy calculations early to assist in glazing selection, shading scheme and other architectural opportunities to reduce loads.
3. Refine these calculations as design develops. Remember to use actual glazing properties, accurately modeled shading, and full credit for lighting reductions due to daylight controls.
4. Use energy simulation data in cost/benefit analysis to explore tradeoffs between envelope improvements, and mechanical first and operating costs.
5. Look for further opportunities to reduce peak loads and energy use throughout schematic design and design development.
6. Plan for HVAC controls, an energy management system, integration with other building system controls, commissioning protocols, and maintenance procedures concurrent with mechanical system design.
7. Flag potential space and ceiling conflicts.
8. Coordinate visible mechanical elements with other design team members.

If you have...

no time

1. Discuss ramifications and opportunities of envelope decisions on comfort and energy with design team during early schematic design.
2. Select energy management strategies that are compatible with lighting controls.
3. Do preliminary load calculations part way through schematic design, using assumptions where necessary, to assist architectural decisions.

a little time

In addition to above:

1. Do load calculations with credit taken for daylighting controls and with shading and glazing properly modeled.
2. Plan for maintenance procedures, controls integration and commissioning now.

more time

In addition to above:

1. Perform several rounds of load calculations, starting from early schematics, to maximize benefit of energy analysis to architectural decisions.
2. Use software that can model daylighting. Consider the use of an outside energy consultant if this software expertise is not available to the design team.